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THE GEOGRAPHIC BIAS IN DETERMINING AVERAGE VARIATIONS OF TOTAL OZONE FROM GROUND-BASED OBSERVATIONS

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At present there are approximately 100 ground stations in the global network routinely observing total ozone. Of these about 85 are in the Northern Hemisphere and 15 in the Southern Hemisphere. Most of the stations in the Northern Hemisphere, about 45, are located between 40-60^{o}N, and in the Southern Hemisphere there are no more than 4 stations in any 10 degree latitude belt. There is legitimate concern that hemispheric variations of total ozone, as reported for instance during the 1960's for the Northern Hemisphere from ground-based observations, may reflect longitudinal shifts of the large scale circulation pattern in the lower stratosphere and consequently a shift in the ozone pattern rather than in the hemispheric mean ozone amount. Even assuming that the reported total ozone values from all stations are equally accurate, and that there is no systematic meteorological bias in the observational frequency or accuracy (as, for instance, resulting from variations in cloudiness), the question still arises as to how the lack of uniform or adequate distribution of ground observing stations might affect the error in determination of global or hemispheric average total ozone amounts and their time variation.

Suggestions for reducing any geographic bias that results from the limited distribution of ground-based observing stations involve optimum interpolation techniques applied to grid point values of observed ozone (Hasebe, 1980), or the use of 3-D general circulation tracer models (e.g., Moxim and Mahlman, 1980). However, the bias can be tested directly by analysis of the observations of total ozone using the data from quasi-global observing systems such as Nimbus-4, or others.

In order to test the bias introduced by the geographic distribution of ground-based total ozone observations, we have compared the mean monthly hemispheric total ozone values as determined from Nimbus-4 BUV observations for the period April 1970 through December 1976 when the hemispheric values are computed from all reported observations, with the mean values when they are calculated from a limited data set corresponding to observations only from those geographic locations where there were ground-based observations.

Comparison between the two sets of data (see Table 1) indicates that the mean difference between the calculated total ozone amount as determined for the entire period from all the satellite data and that derived from the satellite data restricted to location of ground-based stations is 1.3 m-atm cm for the Northern Hemisphere and 0.7 m-atm cm for the Southern Hemisphere (0.3 and 0.2 percent respectively of the average total ozone in each hemisphere). Of more significance, however, is the

Table 1.

Mean and rms differences between all Nimbus-4 BUV data and limited BUV data for computed monthly total ozone amounts for the period April 1970 - December 1976

	Mean diff. (m-atm cm)	%	rms diff. (m-atm cm)	%
Northern Hemisphere	1.3	0.3	7.9	2.0
Southern Hemisphere	0.7	0.2	8.1	2.1
40-50°N	-4.4	1.3	8.0	2.4
40-50°S	3.1	0.9	12.5	4.6

rms difference is a measure of the degree of uncertainty of total ozone changes during the period. Note that the mean and rms differences for the two hemispheres are comparable. There is an obvious trade-off between the fewer number of stations and the decreased natural variability of total ozone in the Southern Hemisphere.

As mentioned earlier, most of the ground-based stations are located in the Northern Hemisphere between 40-60°N. For these latitudes the mean difference between the complete and the limited data sets is slightly larger than for the hemisphere and at least for the latitude belt 40-50°N the difference is negative. This suggests perhaps that at latitudes 40-50°N the ground-based stations may be located chiefly in regions where there are ozone ridges (i.e., where the ozone is higher than the average for the latitude). However, for the north (50-60°N) this does not seem to be the case. The rms differences at the higher latitudes are also larger (12.5 m-atm cm) and represent 3.5 percent of the average zonal total ozone.

If the locations of the M-83 filter ozonometers are eliminated from the comparison (chiefly over the USSR) the mean difference remains the same but the rms difference is increased to slightly more than 16 m-atm cm at 50-60°N indicating the high degree of geographic variability at those latitudes.

For the Southern Hemisphere the rms difference is also quite large at 40-50°S, the region of maximum longitudinal variability.

This analysis suggests that although the long term hemispheric averages of total ozone do not suffer significantly from a geographic bias of the location of ground-based observing stations, the uncertainties in documenting changes of ozone, at least over the seven year period studied, of the order of about 2 percent for each hemisphere and can be as large as 3-5 percent at high latitudes.

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